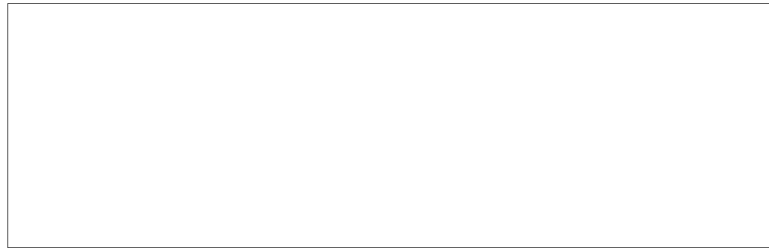


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27 March 1967

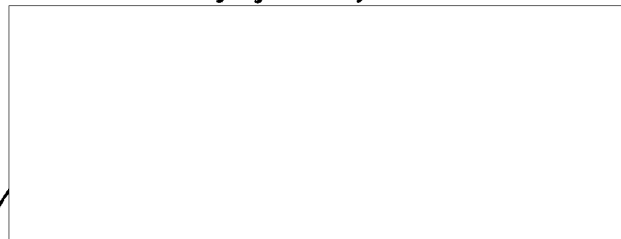
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Enclosed are two copies of our
"Proposed Phase Grating Program" in
response to your letter of 15 March 1967.

Sincerely yours,



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WB:aq

Enclosures: Proposed Phase Grating Program
(2 copies)
Resumes (4) (2 copies each)

PROPOSED PHASE GRATING PROGRAM

Objectives

The objective of the proposed program is to produce in the shortest possible time a grating that can be used in the direct image viewer. The present available gratings show intensity variations in the various orders to an extent that impairs the usability of the instrument.

The most promising road to the fabrication of such a grating seems to be the use of etching techniques. Unfortunately, these processes are fairly complicated and poorly understood. To make a full investigation into all the aspects of this technique will require so much time that this approach seems inadvisable. The technique developed at seems to be so close to the desired end product, that it appears feasible to approach our problem from an empirical standpoint. The desired properties of the grating are well known, and by systematically varying the various production parameters it should be possible to produce gratings that come closer and closer to the desired performance characteristics. The danger of such an approach is that it will come close to the desired results without ever being able to go all the way. We therefore propose to simultaneously investigate, although to a much lesser extent, the physics of the grating. This should lead to guidelines for the production effort by indicating what shape surface would give the desired effects.

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The chemistry of the etching process will not be studied in detail, although we propose to have a chemist associated with the program in order to insure that adequate chemical support is available so as to not impair the speediest road to practical success.

The Desired Grating Qualities

The desired grating specifications are described in the statement of work for [REDACTED], of 25 August 1964, written by [REDACTED]. We would like to discuss these briefly and comment on some of the requirements.

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In Paragraph 3.1.4 the statement is made that any additional orders beyond the sixth on each side are acceptable as long as they are much less in intensity than the first six. This requires a much more complicated grating than we feel is necessary. Initially, when these specifications were written it was felt that the illumination might be a problem, and great stress was placed on preserving as much energy as possible. In actual practice this result was never achieved, and as it turned out there seems to be no great energy problem. We therefore propose to delete this specification and allow the extra orders as long as they do not take an extreme amount of the energy. This would be very unlikely; furthermore these extra orders with diminishing energy will greatly improve the performance of the instrument, since they allow the operator to see the image from a larger area and thus he will be guided to the right position of the head more easily.

In Paragraph 3.1.7 the requirement is made that the minimum amount of light in the lowest intensity order shall be at least 3% of the light falling on the grating. This requirement pertains to a single-line grating and cannot be met in a crossed grating, since the thirteen orders in each direction result in 169 images or orders, and each of them cannot have 3%. We propose to delete this paragraph and require that the energy be distributed as evenly as possible. In light of the remarks made about the required energy, this will not impair the use of the grating for the required purpose.

In Paragraph 3.1.8 it is specified that the lightrays striking the grating shall be parallel. This is not so in the actual instrument. Here the purpose of the grating is to provide multiple images of the aperture in the projection lens as formed by the condensing lenses. The specifications, therefore, should require that the grating provides a continuous array of pupil images when used with the existing optical equipment.

Paragraphs 3.2 to 4.3 will not be applicable to this proposed program.

Experimental Program

In a pragmatic program such as is proposed here, it is extremely important that there be a rigid control on all experimental variables, and that simultaneously, for each change in such parameters, the resultant changes in the physical end product are carefully measured.

We therefore propose to make the set-up to produce these gratings such that all parameters can be carefully controlled. This will require good equipment to control the chemical composition of all solutions used, good temperature control throughout the process, careful timing of each part in process, etc.

Furthermore, the resultant product in each experiment should be carefully studied and the following parameters fully measured. The shape of each individual element in the grating should be known and also the variation of this shape with changes in the production parameters. Furthermore, for each grating the resultant image properties should be carefully studied and measured. Some effort will be made to see if it is possible to explain from a theoretical point of view the resultant image properties from the measured physical shape of the grating. This however is a very complicated process and we do not expect to fully cover this area; we do hope to be able to understand the theory well enough to guide the experimental production process in the right direction, so as to end up with a grating with the desired image properties.

For the measuring of the grating properties we will use the following procedures. For each grating we will measure the shape of the grating elements by various means; microscopy, interference microscopy, etc., and we will possibly measure the phase retardation of coherent light in each grating element. This last measurement might be difficult to do, but would lead to information that is extremely useful. Some effort will, therefore, be made to develop a technique to make these measurements.

To measure the imaging properties of the grating, we will use a laser to study the diffraction effects of the individual grating elements and the diffraction effects of all grating elements combined.

Initially all experiments will be done on glass plates of small size, to ease the efforts in handling and the cost of the experiments. At all times only such procedures will be considered that can be used on 11x11" plates. As soon as we feel confident that we are getting close to the desired grating properties we will start to develop the equipment and techniques to handle the large glass plates.

The emphasis during the total program will be on producing a grating with the desired properties in the shortest possible time.

Facilities and Capabilities of [redacted] in
the Area Required by the Proposed Program

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[redacted] facilities and capabilities to be used in the program will be briefly described in the following section.

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Photographic Facilities-There are two photographic dark-rooms available which are especially constructed for such experimental programs. Besides the normal photographic equipment, they are furnished with air filtering devices to ensure a dust free environment; the water supply is filtered to 1/2 micron. Facilities are available for microdensitometry and micro-photography.

Our personnel is regularly engaged in the fabrication of high precision targets (up to resolving powers of a 1000 lines/mm). We also have the equipment and know-how to produce resist coatings, (at present only 2x2" glass plates can be coated; the enlargement to 11x11" facilities does not present a major problem.)

Chemical Facilities: Chemical laboratory space is presently being built and will be finished before the start of this program. It includes the facilities to handle the chemicals used in glass etching.

Laboratory Facilities: A variety of laboratory equipment and personnel is available to make the various optical measurements on the gratings. Since in this program speed is essential, we plan to build and install some special equipment for this program (see section on equipment needed).

Vacuum Coating Facilities: [] has its own vacuum equipment to supply the necessary coatings which might be needed in this program. Some etching and resist techniques call for vacuum deposited coatings.

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Optical Facilities: In the final product the glass plates used to make the grating will have to be of extremely good optical quality. Our shop is fully equipped to make these plates to any surface quality needed in the program.

For information on the qualifications of the personnel we propose to use on the program, we have included in this proposal the resumes of some of our people.

Special Equipment

Some special equipment will be needed for this program. These fall into two categories: commercially available equipment and equipment to be specially built by []

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Although [] has gas lasers available, this program will call for the continuous use of a laser and we feel that one should be bought for this program so as to be continuously available.

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For the precise measurements of the shape of the grating elements an interference microscope attachment will be needed.

For the exposure of these large gratings a very powerful light source, radiating in the U.V. will be needed. For the smaller experimental samples we have the necessary light sources.

The rest of the needed equipment falls into the category of equipment that will have to be built by []

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[] They include special holders, degreaser, special waterspray equipment, dryers, etc.

The cost of this equipment is included in our price proposal.

Summary

During this program [] will refine the etching technique so as to be capable of producing gratings with properties as specified in the afore-mentioned grating specifications for []

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This will be accomplished in the shortest possible time. We estimate that this will require about one year's time to accomplish the desired goals. The first three months will be used to acquire and build the necessary equipment. The following six months will be used for a systematic trial approach on smaller glass plates; while the last three months will be devoted to fabricating one 11x11" grating. During this last period we will also develop the techniques to produce these gratings in larger quantities.

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